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Contaminant Transport in Soil from a Point Source

S. A. Nta, M. J. Ayotamuno, A. H. Igoni, R. N. Okparanma

***Abstract*—**The work sought to understand the pattern of movement of contaminant from a continuous point source through soil. The soil used was sandy-loam in texture. The contaminant used was municipal solid waste landfill leachate, introduced as a point source through an entry point located at the center of top layer of the soil tank. Analyses were conducted after maturity periods of 50 and 80 days. The maximum change in chemical concentration was observed on soil samples at a radial distance of 0.25 m. Finite element approximation based model was used to assess the future prediction, management and remediation in the polluted area. The actual field data collected for the case study were used to calibrate the modeling and thus simulated the flow pattern of the pollutants through soil. MATLAB R2015a was used to visualize the flow of pollutant through the soil. Dispersion coefficient at 0.25 and 0.50 m radial distance from the point of application of leachate shows a measure of the spreading of a flowing leachate due to the nature of the soil medium, with its interconnected channels distributed at random in all directions. Surface plots of metals on soil after maturity period of 80 days shows a functional relationship between a designated dependent variable (Y), and two independent variables (X and Z). Comparison of measured and predicted profile transport along the depth after 50 and 80 days of leachate application and end of the experiment shows that there were no much difference between the predicted and measured concentrations as they were all lying close to each other. For the analysis of contaminant transport, finite difference approximation based model was very effective in assessing the future prediction, management and remediation in the polluted area. The experiment gave insight into the most likely pattern of movement of contaminant as a result of continuous percolations of the leachate on soil. This is important for contaminant movement prediction and subsequent remediation of such soils.

***Keywords*—**Contaminant, dispersion, point or leaky source, surface plot, soil.

I. Introduction

THE irrational disposal of waste is a major source of soil pollution. Soil pollution leads to modification of the physical, chemical and biological properties of soil. It restricts or prevents the use of soil in various applications where it normally plays a part. Leachate from an unlined landfill contributes to an extensive contamination of soil beneath and adjacent to the dumping area. Leachate is produced in landfill sites by the process of hydrolysis due to the water penetration. Leachate is composed of both organic and inorganic compounds, and their concentration depends on the age of a landfill site [1], [2]. Organic compounds are bio-degradable and its susceptibility to biologic attack varies between different compounds. Many organic contaminants are lipophilic with low water solubility. It implies that they are strongly adsorbed to soil particles and have a low bioavailability. On the other hand, inorganic contaminants cannot be degraded. But their distribution, speciation etc. depends on the environmental factors such as pH and redox potential [3]-[5].

As the municipal solid waste landfill leachate is a combination of various contaminants, soil nearby a municipal solid waste landfill is seen to be influenced with more than one type of contaminant. Because of presence of physically and chemically different contaminants and possibility for interaction between them, sorption and leaching characteristics of chemicals in the mix contaminated soil would be complex.

Contaminant transport models are normally used to ascertain the order of disperse of pollutants and to know whether pollutant occurs above a stipulated level at a particular spot. These models varied from simple mathematical equations to complex computer generated models. A mathematical equation or computer generated model does not provide a unique solution to an environmental problem. It supplies a scenario in regard to specific assumptions and specific input values. Varying certain input parameters can have a considerable influence on the results of a model. Choosing correct boundary conditions and other parameters can be quite case specific.

This research aims at understanding the introduction and subsequent spreading of contaminants from a leaky source to the soil. In this study the contaminants were continually introduced through a single point or port of entry; hence the term leaky source or continuous point source. The overall objective of the study, therefore, is to;

1. Determine the likely behavior of contaminants when introduced into a soil medium from continuous point (leaky) source, and
2. Determine how effective finite different approximation based model in assessing the future prediction, management and remediation in the polluted soil.

II. Materials and Methods

A. Soil

The soil used for the present study was from Uyo village road. It is a sandy loam soil and acidic in nature. The soil was collected from a depth of 0-90 cm. Reference [6] recorded that analysis of the upper layers is relevant in understanding soil interactions with other environmental compartments and the pathways of pollutants between them. The initial chemical contents of the representative samples of test soil was performed through the determination of Manganese,

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Chromium, Cadmium, Copper and Nickel using standard methods.

B. Municipal Solid Waste leachate

The leachate used in this experiment was collected from the Uyo village road waste dumping site in October, 2018. Since the dumpsite was not equipped with a leachate collecting system, the leachate was collected from a hole dug 10 m away from the waste dumping. The sample was then transported to the laboratory and kept in the refrigerator at 4 ^{o}C prior to using in the study.

C. Test Set-up

A rectangular intermediate bulk container (IBC) test tank of dimensions: length, breath and height are 1.12, 0.95 and 0.9 m respectively was used for the experiment. An overhead tank was provided to supply leachate to the soil through a PVC tap system where rate of flow can be controlled. From the overhead tank the leachate is supplied through a PVC perforated pipe, from which it percolates to the soil.

III. Experimental Procedure

Model test was conducted in the developed laboratory set-up to study the leaching process. Test soil was air dried for 28 days and filled in the IBC test tank. The compacted and uncompacted bulk densities of the soils were 13.8 and 12.3 kN/m^3 respectively. At the centre of the tank, above the filled soil, a circular pit of 60 mm diameter and 50 mm depth was prepared. This pit resembles the solid waste dumping place. A circular PVC pipe of 60 mm diameter and 400 mm length was placed at this pit. Perforations were made on the portion of the PVC 50 mm where it is having contact with the soil. Leachate was transferred to the soil through this perforated container. Perforations facilitate the uniform passage of the leachate to surrounding soil. The entire leachate (4.76 litres, approximately 5 litres) was transferred to the soil from the overhead leachate tank to the perforated PVC pipe at a constant rate so as to achieve 50% saturation in 50 days (Fig. 1).

At the beginning of any tests, uncontaminated water was first allowed through the tank to ensure steady state conditions before the municipal solid waste leachate was introduced. This allows for the establishment of a proper outflow condition at the port so that a constant velocity is maintained. A discharge velocity of about 1.157 x 10^{-6} l/sec was used in all experiments. The leachate treated soils were collected from the positions corresponding to 0.25 m and 0.50 m radial distances from the point of application of leachate. The samples were collected after 50 days, i.e., the day at which the application of leachate end), 80 days from the commencement of experiment (Fig. 1).

To collect samples at different depths, PVC pipe of 14 mm diameter and 0.7 m long was introduced at the center radial distances to enable the collection of the sample at the required depth. Samples were collected at different depths and distances. That is, at the soil surface, 0.15, 0.30. 0.45 and 0.60 m at 0.25 and 0.50 m radial distance, as shown in Fig. 2, and analysed for chemical properties. This was done after 50 days were the application of the leachate end and 80 days from the commencement of the experiment.

Fig. 1 Laboratory Test Set-up

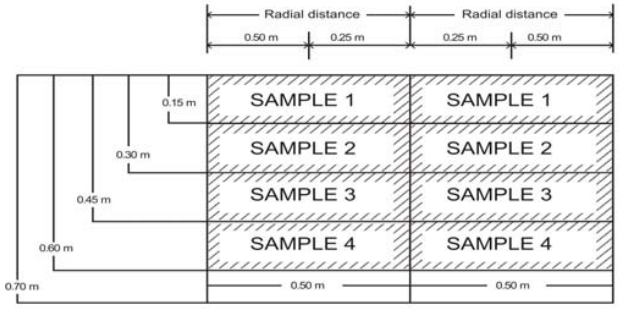

Fig. 2 Samples at Different Depths

A. Chemical Analysis of Samples

The chemical characteristics of the samples were determined as per standard methods published by [7].

B. Development of Leachate Diffusion through Soil Media

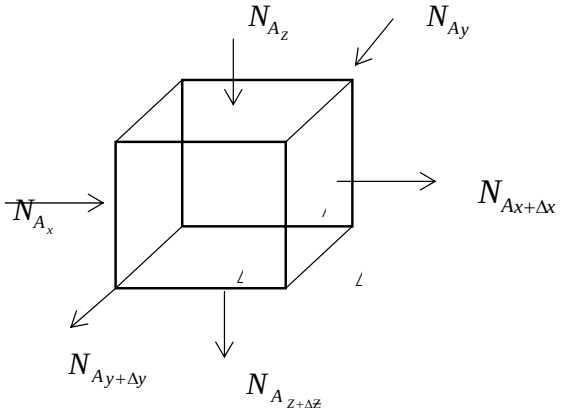

Fig. 3 Representation of Soil Control Volume Element

For the conservation of species A, we applied the general relation for mass balance of species A on the control volume element represented by the box model as:

$$\begin{bmatrix}\text{Rate of accumulation}\\ \text{of A within the control}\\ \text{volume}\end{bmatrix}=\begin{bmatrix}\text{Rate of inflow}\\ \text{of A into control}\\ \text{volume element}\end{bmatrix}-\begin{bmatrix}\text{Rate of outflow}\\ \text{of A from control}\\ \text{volume element}\end{bmatrix}+\begin{bmatrix}\text{Rate of chemical}\\ \text{production of A within the}\\ \text{control volume element}\end{bmatrix} \quad (1)$$

From (1), we have:

$$\text{Rate of accumulation} = (C_{A(t+\Delta t)} - C_{A(t)})\,\Delta x\Delta y\Delta z \quad (2)$$

$$\text{Rate of inflow of A} = \left(N_{A(x)}\right)\Delta y\Delta z\Delta t + \left(N_{A(y)}\right)\Delta x\Delta z\Delta t + \left(N_{A(z)}\right)\Delta x\Delta y\Delta t \quad (3)$$

$$\text{Rate of outflow of A} = \left(N_{A(x+\Delta x)}\right)\Delta y\Delta z\Delta t + \left(N_{A(y+\Delta y)}\right)\Delta x\Delta z\Delta t + \left(N_{A(z+\Delta z)}\right)\Delta x\Delta y\Delta t \quad (4)$$

$$\text{Rate of chemical reaction} = R_A(\Delta x\Delta y\Delta z\Delta t) \quad (5)$$

However, in this study, we have assumed that the rate of production or disappearance of A is negligible and thus, the rate of chemical reaction not considered. Hence, substituting (2) through (5) into (1), and dividing all through by $\Delta x\Delta y\Delta z\Delta t$, we have:

$$\frac{\left(C_{A(t+\Delta t)} - C_{A(t)}\right)}{\Delta t} = \frac{(N_{A(x)} - N_{A(x+\Delta x)})}{\Delta x} + \frac{(N_{A(y)} - N_{A(y+\Delta y)})}{\Delta y} + \frac{(N_{A(z)} - N_{A(z+\Delta z)})}{\Delta z} \quad (6)$$

Taking limit as

$$\Delta t \to 0,\ \Delta x \to 0,\ \Delta y \to 0,\ and\ \ \Delta z \to 0,$$

We have:

$$\frac{\partial C_A}{\partial t} = -\left(\frac{\partial N_A}{\partial x} + \frac{\partial N_A}{\partial y} + \frac{\partial N_A}{\partial z}\right) \quad (7)$$

Letting

$$\nabla N_A = -\left(\frac{\partial N_A}{\partial x} + \frac{\partial N_A}{\partial y} + \frac{\partial N_A}{\partial z}\right) \quad (8)$$

where:

$$\nabla = \frac{\partial}{\partial x} + \frac{\partial}{\partial y} + \frac{\partial}{\partial z} \quad (9)$$

$$N_A = \begin{bmatrix} N_{A(x)} \\ N_{A(y)} \\ N_{A(z)} \end{bmatrix} \quad (10)$$

But the amount of contaminant is related to convective flow and molar flux, hence, have:

$$\left.\begin{aligned} N_{A(x)} &= v_x C_A + J_{A(x)} \\ N_{A(y)} &= v_y C_A + J_{A(y)} \\ N_{A(z)} &= v_z C_A + J_{A(z)} \end{aligned}\right\} \quad (11)$$

Therefore, the differential form of (11) can be expressed in vector form as:

$$\nabla N_A = \nabla\left(\bar{v}.C_A\right) + \nabla J_A \quad (12)$$

So differentiating (12), we have:

$$\nabla N_A = C_A.\nabla\bar{v} + \bar{v}\nabla C_A + \nabla J_A \quad (13)$$

But for constant $\bar{v}$

$$C_A\nabla.\bar{v} = 0 \quad (14)$$

$$\therefore\ \nabla N_A = \bar{v}.\Delta C_A + \nabla J_A \quad (15)$$

From (8),

$$\bar{v}.\nabla C_A = v_x\frac{\partial C_A}{\partial x} + v_y\frac{\partial C_A}{\partial y} + v_z\frac{\partial C_A}{\partial z} \quad (16)$$

Invoking the Fick's first law of diffusion, given by:

$$J_A = -D\ \nabla C_A \quad (17)$$

We have the flux term in (15) as:

$$\nabla J_A = -D\left[\frac{\partial}{\partial x}\left(\frac{\partial C_A}{\partial x}\right) + \frac{\partial}{\partial y}\left(\frac{\partial C_A}{\partial y}\right) + \frac{\partial}{\partial z}\left(\frac{\partial C_A}{\partial z}\right)\right] \quad (18)$$

$$\nabla J_A = -D\left[\frac{\partial^2 C_A}{\partial x^2} + \frac{\partial^2 C_A}{\partial y^2} + \frac{\partial^2 C_A}{\partial z^2}\right] \quad (19)$$

Therefore, combining (15), (16) and (19) we have:

$$\nabla N_A = v_x\frac{\partial C_A}{\partial x} + v_y\frac{\partial C_A}{\partial y} + v_z\frac{\partial C_A}{\partial z} + \left[-D\left(\frac{\partial^2 C_A}{\partial x^2} + \frac{\partial^2 C_A}{\partial y^2} + \frac{\partial^2 C_A}{\partial z^2}\right)\right] \quad (20)$$

Hence, substitution of (20) into (7) gives:

$$\frac{\partial C_A}{\partial t} = -\left(v_x \frac{\partial C_A}{\partial x} + v_y \frac{\partial C_A}{\partial y} + v_z \frac{\partial C_A}{\partial z} \right) + D\left(\frac{\partial^2 C_A}{\partial x^2} + \frac{\partial^2 C_A}{\partial y^2} + \frac{\partial^2 C_A}{\partial z^2} \right) \quad (21)$$

Again, assuming that contaminant's flow in the y-direction is very insignificant, (21) will reduce to:

$$\frac{\partial C_A}{\partial t} = - v_x \frac{\partial C_A}{\partial x} - v_z \frac{\partial C_A}{\partial z} + D_x \frac{\partial^2 C_A}{\partial x^2} + D_z \frac{\partial^2 C_A}{\partial z^2} \quad (22)$$

C. Solution Technique

The solution to (22) can be solved numerically using the appropriate Finite Different Approximation. Thus, resolving the resulting partial differential equation numerically in the explicit scheme, we have:

Time coordinate: Forward difference

$$\frac{\partial C}{\partial t} = \frac{C_{i,j}^{k+1} - C_{i,j}^{k}}{\Delta t} \quad (23)$$

Spatial coordinate:

1. First order partial differential equation: centered difference approximation.

$$\frac{\partial C}{\partial x} = \frac{C_{i+1,j}^{k} - C_{i-1,j}^{k}}{2\Delta x} \quad (24)$$

$$\frac{\partial C}{\partial z} = \frac{C_{i,j+1}^{k} - C_{i,j-1}^{k}}{2\Delta z} \quad (25)$$

2. Second order partial differential equation: centered difference approximation.

$$\frac{\partial^2 C}{\partial x^2} = \frac{C_{i+1,j}^{k} - 2C_{i,j}^{k} + C_{i-1,j}^{k}}{\Delta x^2} \quad (26)$$

$$\frac{\partial C}{\partial z} = \frac{C_{i,j+1}^{k} - 2C_{i,j}^{k} + C_{i,j-1}^{k}}{\Delta z^2} \quad (27)$$

By substituting (23)-(27) into (22) we have:

$$\frac{C_{i,j}^{k+1} - C_{i,j}^{k}}{\Delta t} = -v_x\left(\frac{C_{i+1,j}^{k} - C_{i-1,j}^{k}}{2\Delta x} \right) - v_z\left(\frac{C_{i,j+1}^{k} - C_{i,j-1}^{k}}{2\Delta z} \right) + D_x\left(\frac{C_{i+1,j}^{k} - 2C_{i,j}^{k} + C_{i-1,j}^{k}}{\Delta x^2} \right) + D_z\left(\frac{C_{i,j+1}^{k} - 2C_{i,j}^{k} + C_{i,j-1}^{k}}{\Delta z^2} \right) \quad (28)$$

or

$$C_{i,j}^{k+1} - C_{i,j}^{k} = -\frac{\Delta t v_x}{2\Delta x}\left(C_{i+1,j}^{k} - C_{i-1,j}^{k} \right) - \frac{\Delta t v_z}{2\Delta z}\left(C_{i,j+1}^{k} - C_{i,j-1}^{k} \right) + \frac{\Delta t D_x}{x^2}\left(C_{i+1,j}^{k} - 2C_{i,j}^{k} + C_{i-1,j}^{k} \right) + \frac{\Delta t D_x}{\Delta z^2}\left(C_{i,j+1}^{k} - 2C_{i,j}^{k} + C_{i,j-1}^{k} \right) \quad (29)$$

For further simplicity, (29) can be written as:

$$C_{i,j}^{k+1} - C_{i,j}^{k} = -\alpha\left(C_{i+1,j}^{k} - C_{i-1,j}^{k} \right) - \beta\left(C_{i,j+1}^{k} - C_{i,j-1}^{k} \right) + \gamma\left(C_{i+1,j}^{k} - 2C_{i,j}^{k} + C_{i-1,j}^{k} \right) + \Gamma\left(C_{i,j+1}^{k} - 2C_{i,j}^{k} + C_{i,j-1}^{k} \right) \quad (30)$$

Collection of like terms, gives:

$$C_{i,j}^{k+1} = (\alpha + \gamma) C_{i-1,j}^{k} + (\beta + \Gamma) C_{i,j-1}^{k} - (2\gamma + 2\Gamma - 1) C_{i,j}^{k} - (\alpha - \gamma) C_{i+1,j}^{k} - (\beta - \Gamma) C_{i,j+1}^{k} \quad (31)$$

where:

$$\alpha = \frac{\Delta t v_x}{2\Delta x}, \beta = \frac{\Delta t v_z}{2\Delta z}, \gamma = \frac{\Delta t D_x}{\Delta x^2}, \Gamma = \frac{\Delta t D_z}{\Delta z^2}$$

Equation (31) is the numerical solution to (22); MATLAB was used for simulation of the results obtained from the process.

The diffusion coefficients of each pollutant in x and z-directions can be obtained by assuming the following:

1. That diffusion of pollutants in the leachate is in a steady state.
2. That $D_x = D_z$.
3. That velocity in x-direction is about 10 times that in z-direction.

Thus,

$$D\frac{d^2 C}{dx^2} + v\frac{dC}{dx} = 0 \quad (32)$$

The solution to (32) can be obtained from the auxiliary equation as follows.

$$Dm^2 + vm = 0 \quad (33)$$

Thus, we have:

$$m = \frac{-v \pm \sqrt{v^2}}{2D} \quad (34)$$

$$m = \frac{-v + v}{2D} = 0 \quad (35)$$

$$m = \frac{-v - v}{2D} = -\frac{v}{D} \quad (36)$$

For real and different roots, we have the solution to the

model equation as:

$$C = A\exp(0)x + B\exp\left(-\frac{v}{D}x\right) \quad (37)$$

$$C = A + B\exp\left(-\frac{v}{D}x\right) \quad (38)$$

To obtain values for the constants, we use the boundary conditions as follows. At $x = 0$; $C = C_o$

Equation (38) becomes:

$$C_o = A + B \quad (39)$$

Again, at $x = \infty$; $C = 0$, (38) becomes:

$$A = 0 \quad (40)$$

Thus, from (11), we have:

$$B = C_o \quad (41)$$

Substituting (40) and (41) into (38) gives

$$C(x) = C_o \exp\left(-\frac{v}{D}x\right) \quad (42)$$

From the slope of $\ln C(x)$ versus x, the diffusion coefficients of pollutants can be obtained, with known seepage velocity.

IV. Results and Discussions

Table I shows the chemical composition of the municipal solid waste landfill leachate used in the experiment. Table ÎI and III show direct results from the experiment after 50 and 80 days from were application of the leachate end and the stoppage of the experiment recovered at 0.25 and 0.50 m radial distance and at the soil surface, 0.15, 0.30, 0.45 and 0.60 m depth from the point of application of leachate. It can be observed that the presence of chemicals is found to be maximum at 0.25 m radial distance from the point of leachate application and at the soil surface. This may be due to the pattern of flow path of the leachate through the soil that is, point or leaky source.

TABLE I
Chemical Composition of the Municipal Solid Waste Landfill Leachate Used in the Experiment

Details	Leachate
Mn (mg/l)	125.25
Cu (mg/l)	8.67
Cr (mg/l)	0.021
Cd (mg/l)	0.059
Nickel (mg/l)	0.355

TABLE II
Experimental Results after 50 Days

Depth (m)	Mn (mg/kg)		Cu (mg/kg)		Cr (mg/kg)		Cd (mg/kg)		Ni (mg/kg)	
	0.25 m	0.50 m	0.25 m	0.50 m	0.25 m	0.50 m	0.25 m	0.50 m	0.25 m	0.50 m
0	7.89	6.94	2.24	1.84	12.9	11.5	1.23	1.04	6.45	5.17
0.15	7.14	6.42	1.6	1.36	11.2	10.3	1.06	0.91	5.55	4.82
0.3	6.31	5.66	1.54	1.18	10.1	8.71	0.84	0.64	4.75	3.45
0.45	5.22	4.58	1.39	1.05	8.3	6.05	0.65	0.47	4.6	2.96
0.6	4.71	4.13	1.24	0.93	8.15	5.65	0.31	0.15	4.2	2.65

TABLE III
Experimental Results after 80 Days

Depth (m)	Mn (mg/kg)		Cu (mg/kg)		Cr (mg/kg)		Cd (mg/kg)		Ni (mg/kg)	
	0.25 m	0.50 m	0.25 m	0.50 m	0.25 m	0.50 m	0.25 m	0.50 m	0.25 m	0.50 m
0	5.62	4.79	1.54	1.19	10.3	8.32	0.93	0.77	3.51	2.81
0.15	4.84	3.68	1.13	0.98	8.57	6.62	0.61	0.49	3.26	2.24
0.3	4.37	3.26	0.82	0.74	7.05	4.47	0.44	0.38	2.48	1.93
0.45	4.12	3.51	0.58	0.41	5.67	3.42	0.37	0.26	1.83	1.38
0.6	3.87	3.08	0.39	0.18	5.52	3.02	0.19	0.09	1.29	0.96

Figs. 4-8 show plots for determination of dispersion coefficient for Mn, Cu, Cr, Cd and Ni at 0.25 and 0.50 m radial distance at the soil surface (0.0), 0.15, 0.30, 0.45 and 0.60 m depth from the point of application of leachate. This shows a measure of the spreading of a flowing leachate due to the nature of the soil medium, with its interconnected channels distributed at random in all direction. The equation 'y' in the figures shows the relationship between the natural log of the concentration (InC) and the depth X in metres (m). R2 stands for coefficient of determination or correlation coefficient. The value indicates how well the trend line corresponds to the data. The closer R2 to 1 the better the fit or result.

Figs. 9-13 show surface plots of Mn, Cu, Cr, Cd and Ni transport in soil after 80 days. Surface plots show a functional relationship between a designated dependent variable (Y), and two independent variables (X and Z). The plot is a companion plot to the contour plot.

Figs. 14-23 show comparison of measured and predicted profile of Mn, Cu, Cr, Cd and Ni transport along the depth after 50 and 80 days of leachate application and stoppage of

the experiment. From the figures it can be observed that there is no much difference between the predicted and measured concentrations as they are lying close to each other. For the analysis of contaminant transport, finite different approximation based model was found to be effective in assessing future prediction, management and remediation measures in the polluted area.

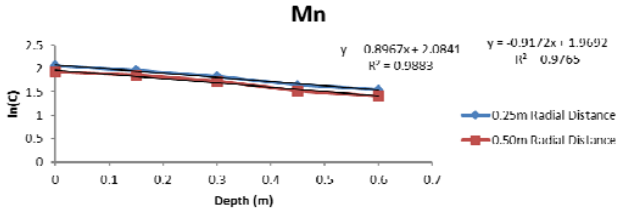

Fig. 4 Determination of Dispersion Coefficient for Mn at 0.25 and 0.50 m Radial Distance

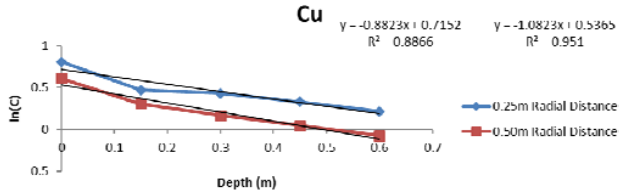

Fig. 5 Determination of Dispersion Coefficient for Cu at 0.25 and 0.50 m Radial Distance

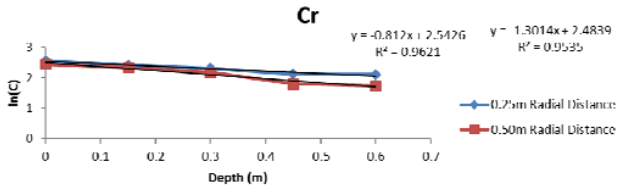

Fig. 6 Determination of Dispersion Coefficient for Cr at 0.25 and 0.50 m Radial Distance

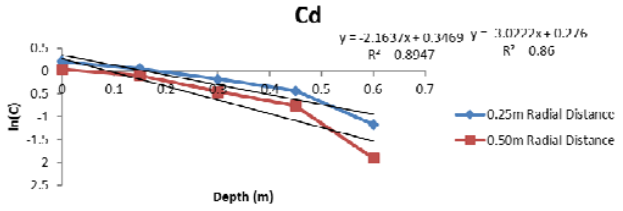

Fig. 7 Determination of Dispersion Coefficient for Cd at 0.25 and 0.50 m Radial Distance

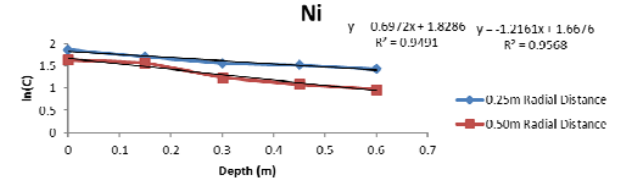

Fig. 8 Determination of Dispersion Coefficient for Ni at 0.25 and 0.50 m Radial Distance

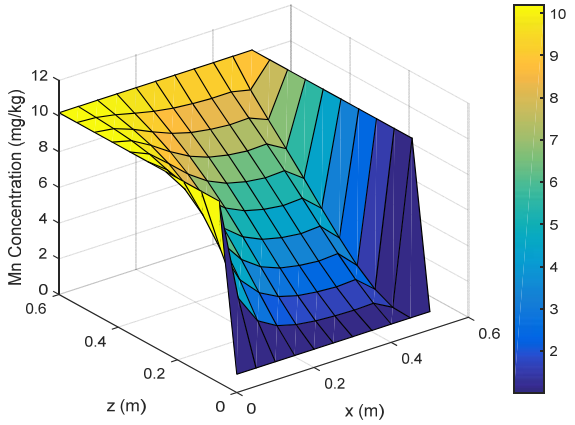

Fig. 9 Surface Plot Showing Profile of Manganese Transport in Soil after 80 Days

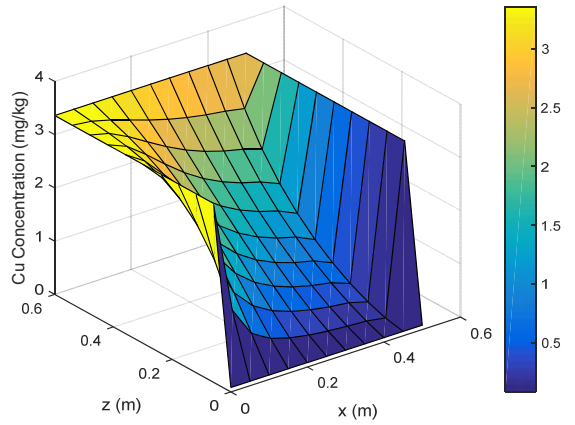

Fig. 10 Surface Plot Showing Profile of Copper Transport in Soil after 80 Days

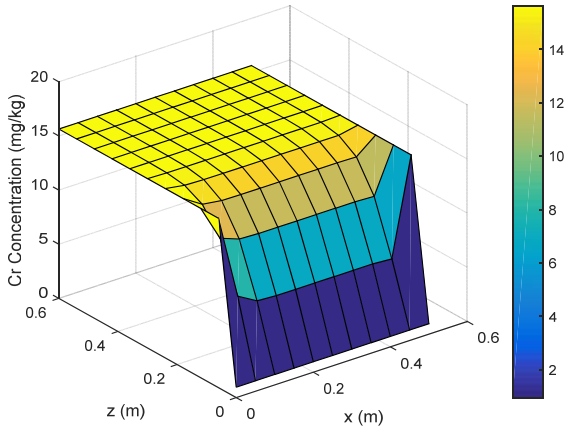

Fig. 11 Surface Plot Showing Profile of Chromium Transport in Soil after 80 Days

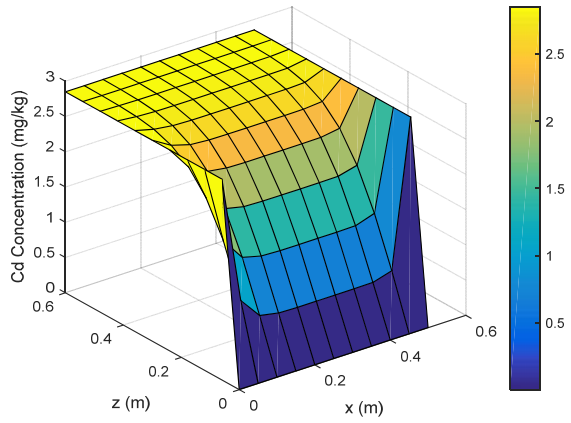

Fig. 12 Surface Plot Showing Profile of Cadmium Transport in Soil after 80 Days

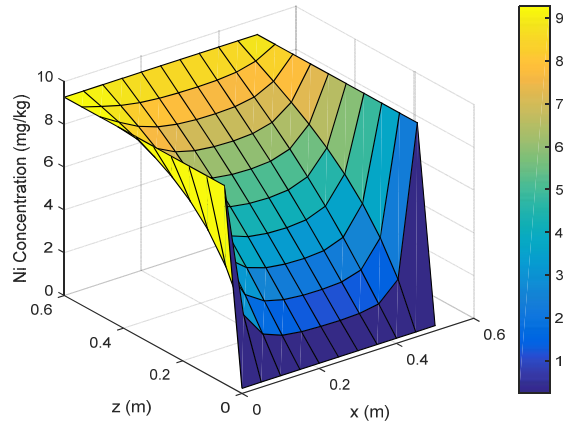

Fig. 13 Surface Plot Showing Profile of Nickel Transport in Soil after 80 Days

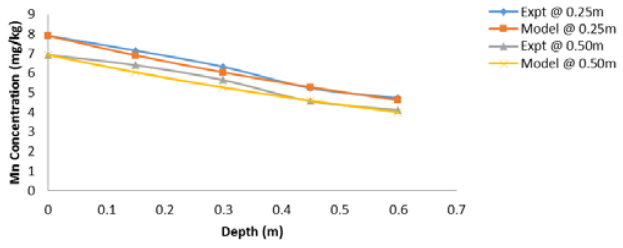

Fig. 14 Measured and Predicted Profile of Mn Transport after 50 Days

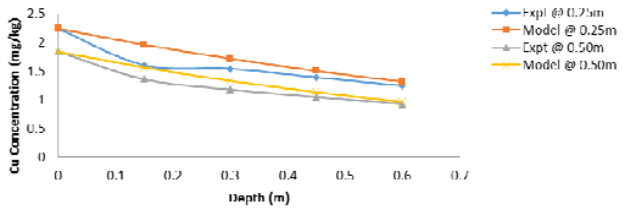

Fig. 15 Measured and Predicted Profile of Cu Transport after 50 Days

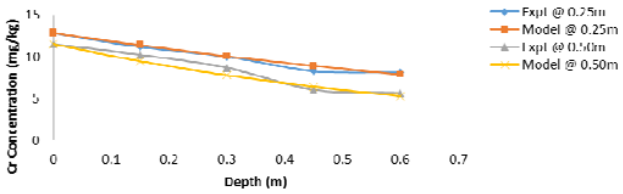

Fig. 16 Measured and Predicted Profile of Cr Transport after 50 Days

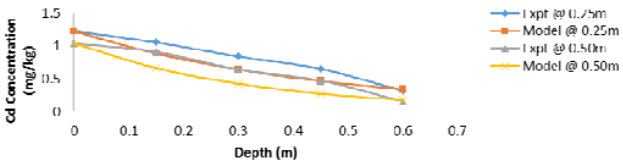

Fig. 17, Measured and Predicted Profile of Cd Transport after 50 Days

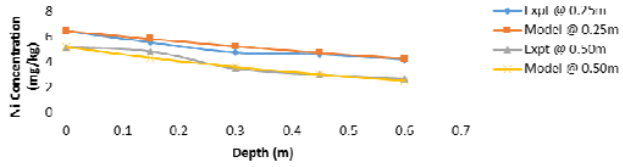

Fig. 18 Measured and Predicted Profile of Ni Transport after 50 Days

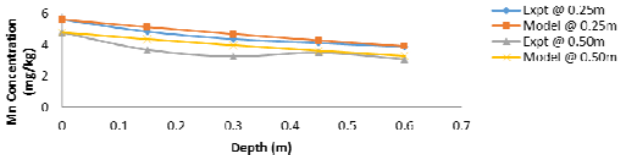

Fig. 19 Measured and Predicted Profile of Mn Transport after 80 Days

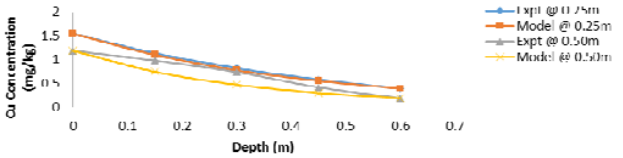

Fig. 20 Measured and Predicted Profile of Cu Transport after 80 Days

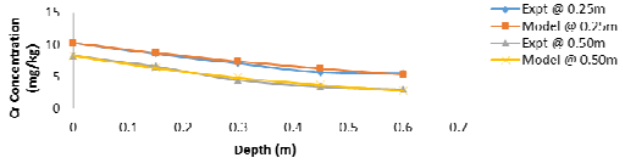

Fig. 21 Measured and Predicted Profile of Cr Transport after 80 Days

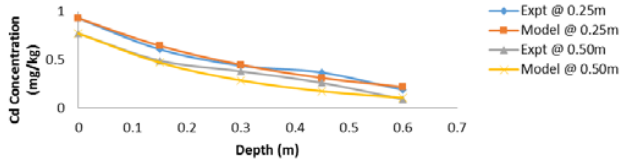

Fig. 22 Measured and Predicted Profile of Cd Transport after 80 Days

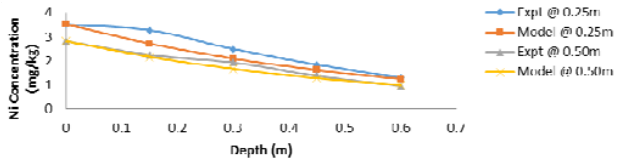

Fig. 23 Measured and Predicted Profile of Ni Transport after 80 Days

V. Conclusion

The aim of the research was to understand the mechanism of contaminant transport from a continuous point (leaky) source through soil. The plots for determination of dispersion coefficient at 0.25 and 0.50 m radial distance from the point of application of leachate show a measure of the spreading of a flowing leachate due to the nature of the soil medium, with its interconnected channels distributed at random in all direction. Surface plots of metals on soil after 80 days show a functional relationship between a designated dependent variable (Y), and two independent variables (X and Z). Comparison of measured and predicted profile transport along the depth after 50 and 80 days of leachate application and stoppage of the experiment show that there is no much difference between the predicted and measured concentrations as they are all lying close to each other. For the analysis of contaminant transport, finite different approximation based model was very effective in assessing the future prediction, management and remediation in the polluted soil. The findings of this research are presently being used in studies involving soil and contaminant and their treatment using solidification and stabilization method.

Acknowledgments

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